Naval Aviation Enterprise Corrosion Prevention Team

Army Corrosion Summit

3-5 February 2009

Report Documentation Page

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Reduce the Cost of Corrosion: Today and Tomorrow

Phase 1
New Aircraft

Establish Corrosion Contract Language and Define Corrosion Performance Criteria
Develop Standard Verification and Validation Criteria for Environmental Performance
Promulgate Corrosion Prevention and Control Guidance and Policy
Establish and Support Corrosion Prevention Action Teams
Revitalize Corrosion S&T
Incorporate Lessons Learned

Phase 3
Late Mature Stage

Service Life Assessment and Service Life Extension
Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
Implement New Repair Technologies
Feed Lessons Back to Early Mature and New Aircraft

Lust

Corrosion Stages of Life

Dust

Phase 2
Early Mature Stage

Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
Demonstrate, Validate and Implement New Technologies
Conduct Validation and Verification Inspections for Unproved Materials
Establish Improved Data Collection Methods
Standardize Data Assessment Methods
Feed Lessons Back to New Aircraft

Phase 4
Final Life Stage

Apply Advanced Inspection Techniques to Minimize Airframe and Component Disassembly
Reduce Component Scrap Rate Through Emergent Remanufacturing Technologies
Capture Lessons Learned and Fleet Data and Feed Back to Other Stages of Life

Cost of Corrosion
Schedule and Cost Estimates

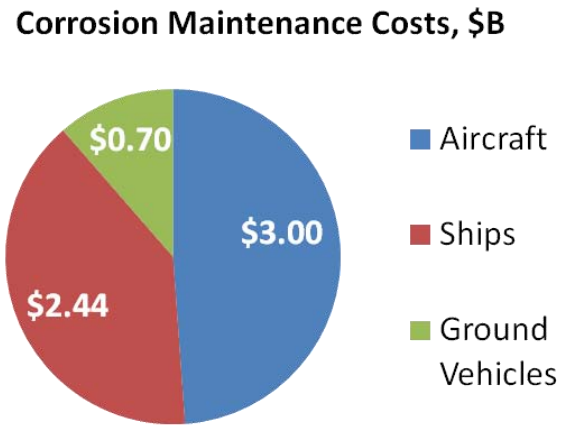
(from LMI Cost of Corrosion Report MEC70T3, May 2008)

Year	Study area	Costs	Cum.
2004/05	Air Force (USAF funded, USAF methodology)	**$1.5B**	**$1.5B**
2005/06	Army ground vehicles (FY2004 data)	**$2.0B**	**$3.5B**
2005/06	Navy ships (FY2004 data)	**$2.4B**	**$5.9B**
2006/07	DoD facilities (FY2005 data)	**$1.8B**	**$7.7B**
2006/07	Army aviation and missiles (FY2005 data)	**$1.6B**	**$9.3B**
2006/07	Marine Corps ground vehicles (FY2005 data)	**$0.7B**	**$10.0B**
2007/08	Navy and Marine Corps aviation (FY2005 and FY2006 data)	**$3.0B**	**$13.0B**
2007/08	USCG aviation and ships (FY2005 and FY2006 data)	**$0.3B**	**$13.3B**
2008/09	Air Force aviation and repeat Navy ships and Army ground vehicles		
2009/10	Repeat FY2006/FY2007		

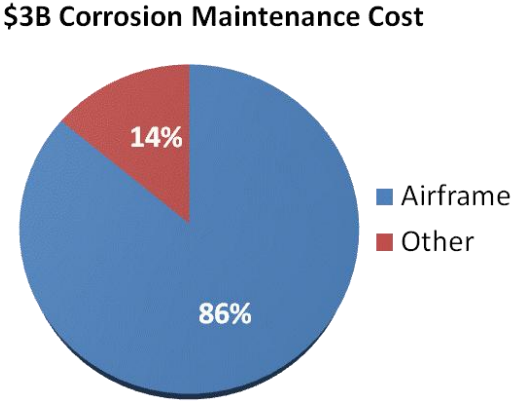
Total Navy Annual Cost of Corrosion: ~$6.1B
~46% of DoD/CG Total

Impact of Corrosion on Navy/NAE

Total Navy Cost



NAE Cost



"death by a thousand cuts"

Maintenance and Corrosion Costs

NAE

(from LMI Cost of Corrosion Report MEC70T3, May 2008)

Estimated annual depot costs

Node or sub-node	Description of corrosion cost node	Total aviation and engine maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion cost as a percentage of total aviation and engine maintenance cost
A1	Navy organic depot direct labor	$649	$318	48.9%
A2	Marine Corps organic depot direct labor	$292	$172	58.8%
A3	Navy commercial depot labor	$308	$154	49.8%
A4	Marine Corps commercial depot labor	$165	$79	47.9%
B1	Navy organic depot materials	$646	$256	39.7%
B2	Marine Corps organic depot materials	$232	$91	39.2%
B3	Navy commercial depot materials	$606	$248	40.9%
B4	Marine Corps commercial depot materials	$344	$140	40.6%
	Depot overhead	$127	$0	0%
	Depot total	$3,369	$1,458	43.3%

Estimated annual field costs

Node or sub-node	Description of corrosion cost node	Total aviation and engine maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion cost as a percentage of total aviation and engine maintenance cost
C1	Navy organic field-level direct labor	$3,197	$974	30.5%
C2	Marine Corps organic field-level direct labor	$920	$212	23.0%
C3	Navy commercial field-level labor	$176	$50	28.5%
C4	Marine Corps commercial field-level labor	$97	$23	24.0%
D1	Navy organic field-level materials	$689	$121	17.6%
D2	Marine Corps organic field-level materials	$324	$51	15.7%
D3	Navy commercial field-level materials	$56	$7	13.1%
D4	Marine Corps commercial field-level materials	$30	$5	16.5%
	Field-level overhead	$358	$0	0%
	Field-level total	$5,847	$1,443	24.7%
E	Labor of non-maintenance aviation operators	$88	$35	39.8%
F	Priority 2 and 3	$3	$3	N/A
G	Purchase cards	$16	$16	N/A
	Outside normal reporting total	$107	$54	N/A
	Total-all costs	$9,323	$2,955	31.7%

TMS Cost Rank/Combined

No.	TEC	TMS	Corrosion cost per item (in millions)	Per-item corrosion cost rank	Total corrosion cost (in millions)	Total corrosion cost rank	Combined Rank	
1	AAED	EA-6B	$1.7	2	$193.8	3	5	retiring
2	AHZA	SH-60B	$1.4	4	$202.3	2	6	retiring
3	AMAF	FA-18C	$1.0	7	$382.3	1	8	
4	APBD	P-3C	$1.1	6	$179.7	4	10	
5	AHZB	SH-60F	$0.9	10	$63.9	9	19	retiring
6	AHRH	CH-46E	$0.7	15	$148.6	5	20	retiring
7	AMAH	FA-18E	$0.6	18	$68.8	6	24	
8	ACZB	C-9B	$1.6	3	$26.9	21	24	
9	AEBC	E-2C	$0.9	13	$58.0	12	25	
10	AHCS	VH-3D	$2.1	1	$23.6	24	25	retiring
11	AFXD	F-5N	$1.3	5	$25.1	22	27	
12	AHXD	CH-53E	$0.4	24	$65.8	7	31	
13	AHXJ	MH-53E	$0.9	12	$27.9	19	31	
14	ACWA	C-2A	$0.8	14	$27.9	18	32	
15	AHZN	MH-60S	$0.5	19	$46.7	14	33	
16	ACMC	C-130T	$0.9	9	$19.0	26	35	
17	AMAG	FA-18D	$0.4	26	$59.5	10	36	
18	ASBE	S-3B	$0.6	17	$27.3	20	37	retired
19	AFWE	F-14D	$0.9	11	$18.4	27	38	retired
20	AMAJ	FA-18F	$0.4	27	$58.5	11	38	

NAE Corrosion Effort Background

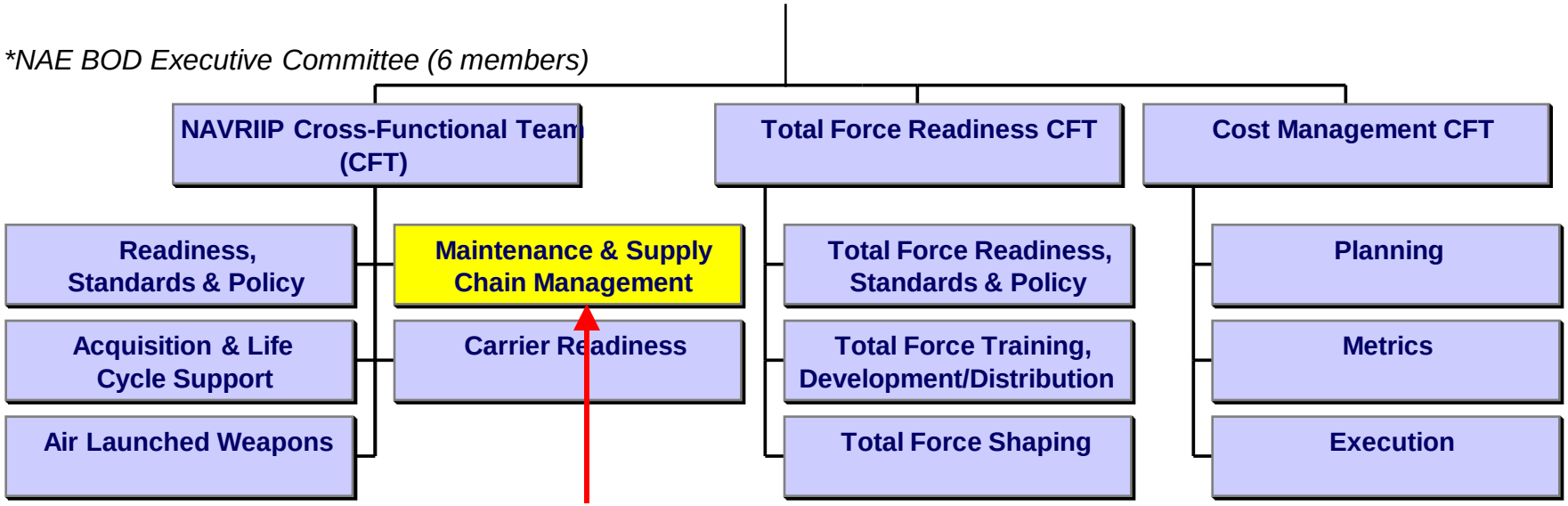
- Nov 2005 to Feb 2007 – AIR 4.3.4 (Materials Engineering Division) advocated for improved coordination, planning, and execution of corrosion efforts across the NAE
- Feb 2007 – AIR 4.0 stakeholder meeting regarding assessment corrosion is costing Navy $1B/1M MMHRS annually
  - source: Air 4.2 Dr Stoll and Air 6.0 Conroy cost assessments
  - the “should” cost has never been assessed and is a key topic for the new Corrosion Cost Working Group
- Jun 2007 NAE BOD briefed corrosion significantly impacting RFT gap across multiple T/M/S
  - source: CAPT Trainer, OPNAV N42
- Jul 2007 NAE BOD sponsors Corrosion Prevention Team (CPT)
  - Corrosion lead- RDML Mike Hardee (AIR-6.0)
  - NAE CPT is a multi-competency, multi-disciplinary team (CNAF, CNATT, Air 1.0/4.0/6.0, COMFRC, etc.)
- Sept 2007 NAE CPT Aligned Within M&SCM Goal 1, RFT Gap Closure
  - first formal link to BOD

Governance

Board of Directors (BOD)

*Commander, Naval Air Forces (CNAF), CEO	US Marine Corps Aviation (USMC AVN)
*Commander, Naval Air Systems Cmnd. (NAVAIR), COO	Naval Strike Air Warfare Center (NSAWC)
*Commander, Naval Air Forces Atlantic (CNAL)	Naval Supply Systems Command (NAVSUP)
*TFR Officer (AIR 1.0, NAVAIR)	Operational Test & Evaluation Force (OPTEVFOR)
*Chief Financial Officer (AIR 6.8, NAVAIR)	Commander, US Fleet Forces Command (CFFC, N4/7)
N43, N82, *N88	Chief of Naval Air Training (CNATRA)
Deputy Assistant Secretary of the Navy, Air	Commander, Naval Air Forces Reserve (CNAFR)
Deputy Assistant Secretary of the Navy, Logistics	
Naval Education & Training Command (NETC)	**Naval Sea Systems Command (NAVSEA)**
Navy Military Personnel Command (NMPC)	**Space & Naval Warfare Systems Command (SPAWAR)**
Naval Network Warfare Command (NETWARCOM)	**Commander, Naval Installations (CNI)**

**NAE BOD Executive Committee (6 members)*



Corrosion Prevention Team Link to BOD

Link to BOD

➢ Aligned Under M&SCM GOAL 1

Goal 1: Cost-wise Aircraft RFT Entitlement

Goal Team 1A:	CWRIIP
Goal Team 1B:	Component Reliability
Goal Team 1C:	Corrosion Control

- Achieve Optimal Aircraft Readiness
- Reduce RFT Gap To Less Than 5%
- Reduce RFT Gap Of Each TMS By 20.0%

➢ M&SCM Goal 1C –Corrosion Control

"Improve Airframe Material Condition Through Systematic Corrosion Abatement Strategies As Assessed At Scheduled Corrosion Inspections Throughout The Maintenance System."

M&SCM Goal 1C Corrosion

FY09 Goals/Deliverables

Develop & Apply Corrosion Focus Area List for:
- E-2/C-2
- H-60
- H-53

- Complete H-60 RCA Study; ID & Implement Improvement Opportunities
- Complete Training Gap Analysis
- Draft Air Vehicle Circular (AVC)
- Establish Cost of Corrosion Baseline for F/A-18

Progress

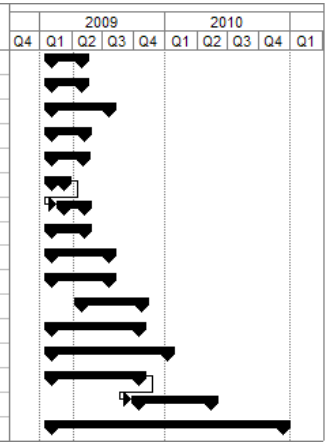
- TMS Deployment Plan Implementation Underway
- E-2/C-2 FAL delivered & applied on MCI Events
- H-60 RCM/FAL - Working with FST/PMA to develop completion strategy
- H-53 FAL Developed, RFU at pilot start
- H-60 RCA study site visits complete. Results analysis underway
- Training GAP Analysis in-work ECD Jul
- AVC in-work, completed draft ECD Jan
- Working w/RESET to Calculate CoC Baseline ECD TBD

Barriers (B) and Mitigation (M)

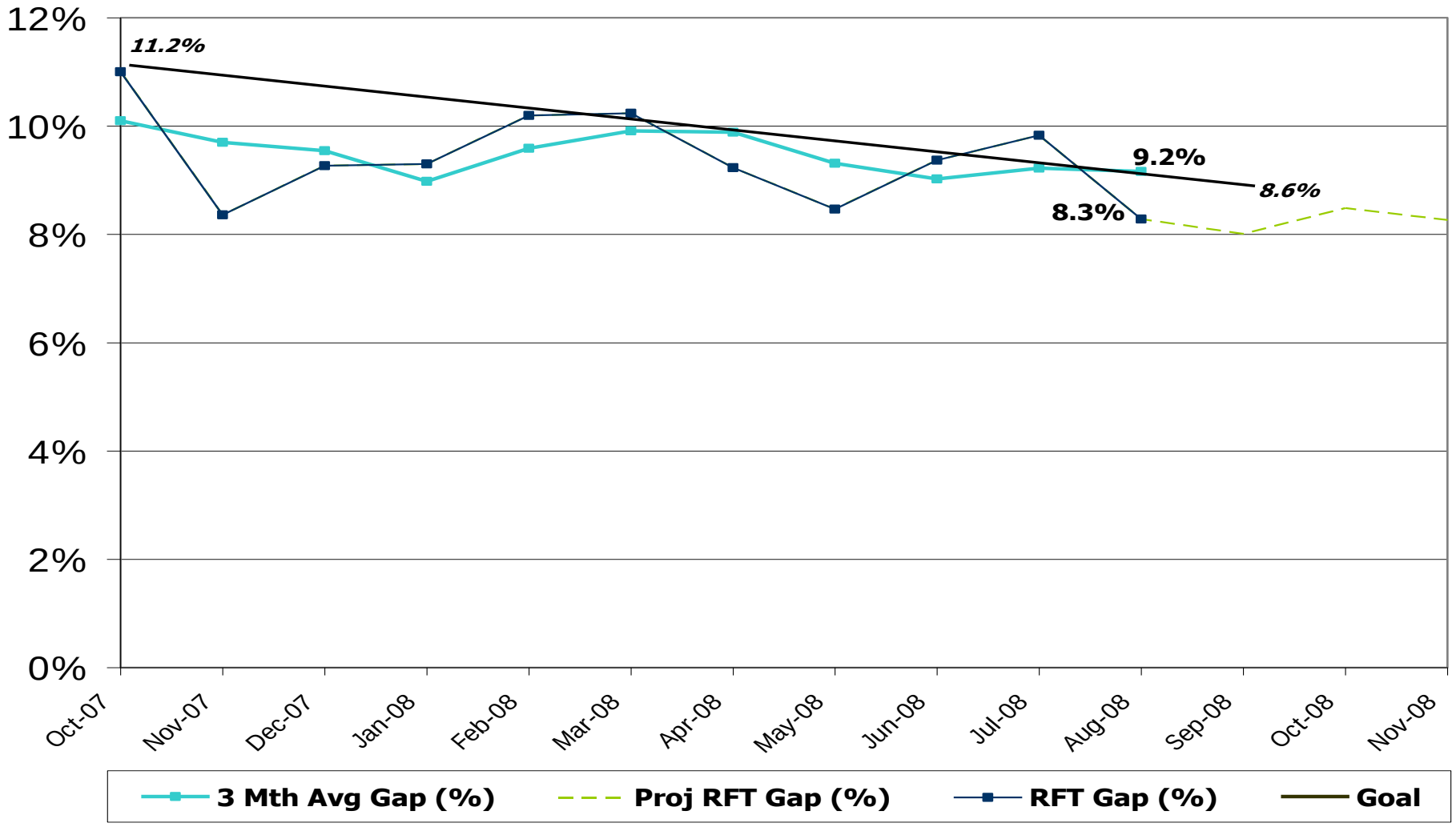
- **(B)** Inconsistent Data & Analysis across TMS
  (M) FRC Southwest modifying ADCS to improve data capture accuracy. Deploy to FRC East & Southeast.
  (M) AIR-4.0 RCM Lead will Standardize Data & Analysis processes across all TMS FST's
  (M) Working to rollout ADCS to Type Wings
- **(B)** H-60 RCM Analysis unfunded
  (M) Fund RCM Analysis

Future Plans/Timelines

ID	WBS	Task Name
1	1	CNAF Roll Out Plan
2	1.1	Implement CPT 4790.2 Changes
14	2	Corrosion Prevention Team Fleet Pilot Program
15	2.1	F/A-18 Pilot Program
16	2.1.1	ID Corrosion Areas & Produce FAL
21	2.1.2	TMS MCI Instruction incorporating FAL
27	2.1.3	Monitor FAL Grading Results
46	2.2	E-2 Pilot Program
92	2.3	H-53 Implementation
124	2.4	H-60 Implementation
156	3	FRC Aircraft Completion Delivery Letter Coordination
162	4	Value Stream Corrosion Prevention/Control Life Cycle Process Mapping
169	5	Perform F/A-18 HPC Study
176	6	Perform H-60 RCA Study
183	7	Perform Training GAP Study
189	8	Deploy MCI ADCS



All Navy (w/out CNATRA)
RFT Gap (%) FY 08



What Is Needed

- **Establish Expectations**
  - Baseline Airframe Material Condition
  - Reduce Maintenance System Variation
  - Determine Should Be and Actual Costs
  - Reduce Corrosion Impact By Improving Corrosion Resistance in Design
- **Establish Communication And Feedback**
  - FRC E&E, FST, Wing MCI, Squadron, AIR-1.0/4.0/6.0, CNAF
- **Integrate With/Be Supportive Of Existing Related Processes**
  - USMC Reset, AIR 4.0 Future Readiness, IMC/RCM, WLS Process, Distance Support, Enterprise Airspeed
- **Rectify Fragmented Activity – Design Holistic System Approach For Standardization Of Corrosion Prevention/ Treatment**
  - Understanding Of System Interactions, Ownership
  - Common Assessment/ Reporting Process/ Metrics
  - All Stakeholders Part Of Solution – Integrated Team With Regular Mtgs, Joint Products And Coordinated Objectives
  - Affect Entire Life Cycle

Basis For Components Of Strategy

Strategy

Acquire — Sustain — Retire




- Expectation Management
- Communication, Integration, Standardization
- Feedback To Future Readiness
- Link To Cost
- System Design Map
- Establish Metrics, Requirements, Funding

CNAF

FRC

NAVAIR

CNATT

Enterprise AIR*Speed*

RESET

Distance Support

NATEC

Tactical Components of Strategy

COMPONENT	ACTIVITY	EXPECTED OUTCOME
Baseline Material Condition Expectation Process (Team I.D.'d and Launched)	• Develop foundational standardized process guidance for BMCE development by FSTs • FSTs develop TMS specific BMCE	• Set expectations for mat'l condition • Quantify effectiveness of maint system • Establish "norms" and triggers • Provide corr data that will enable stakeholders to make informed decisions
Implement Mat'l Condition Assessment @ FRCs/Wings (Team I.D.'d and Launched)	• Utilize 'depot' E&E artisans to inject FST developed mat'l condition expectations during planned Type Wing MCI inspections	• Early injection of knowledge to Fleet • Immediate identification and prevention/mitigation of corr • Minimize variation • Communication/feedback regarding maint system effectiveness
Value Stream Map Corrosion Prevention/Control Life Cycle Process (Team I.D.'d and Launched)	▪ Capture and convert data to CPI activity and mitigation strategies ▪ Corrosion response, assessment and mitigation HICVS	• Identify, link and align all on-going activity • Targeted efforts • Data source tracking • Identification of policy owners
Future Readiness (Team I.D.'d and Launched)	• Identify design opportunities/shortfalls and create feedback loop to Future Readiness Team • Develop improved corr contract language	• More reliable future weapons systems • Increased acquisition awareness of areas req'ing design chgs/improvements/mods • Improved SOWs
Cost Development (Team I.D.'d and Launched)	• Link corr effects on a/c to expended costs (LMI Study???) • Identify "should costs" • Work to mitigate delta	• Targeted efforts • Biggest "bang for the buck" • Increased awareness for focused decision making

NAE Corrosion Root Cause Assessment

• **Genesis**: effort derived from a root cause analysis for wiring failures at fleet level

• **Status**: multi-year plan to assess root cause factors for corrosion issues with Navy and Marine Corps aircraft

• **Support**: CNAF and NPRE funding

• **Impact**: F/A-18s and H-60s make up 38% of NAE aircraft in FY09

2007

2008

2009

Highlights

- **CNATT/HPC Human Performance Assessment on EA-6Bs and F/A-18's (Completed)**
  - Solutions include changes to Policy, Training, Technologies and processes and practices.
- **Impact of corrosion on the NAE Assessed (Current Readiness (minimal), Future Readiness (major), Safety (minor), Cost (major))**
- **Goal to Link efforts across platforms and from legacy to new**
- **Provides fleet driven needs back to logistics and engineering**

Key Outcome: Balanced approach to reduce impact of corrosion on NAE

NAE Corrosion Initiative

Acquire — Sustain — Retire

Future Readiness Team is Focused on Solutions in Acquisition so that Current Problems are Minimized 20 Years from Now

New to fleet: EA-18G, V-22, H-60R/S, UH-1Y/AH-1Z
Next decade: P-8A, F-35B/C, MQ-8B, VH-71A, H-53K, BAMS, E-2D
2 Decades: FA-XX, EP-X

Future Readiness Thrusts

- **Corrosion Resistant Design**
  - Influence requirements documentation to include corrosion prevention guidance
  - Influence future contract language to include corrosion prevention activities
  - Influence technical guidance documentation (SETR / Risk Management)
  - Require life-cycle corrosion cost documentation at design review
  - Maximize effectiveness and implementation of corrosion prevention and control plans and corrosion action teams
- **Standardized Technical Criteria & Data**
  - Establish standard corrosion validation & verification criteria for NAE
    - Airframe, Avionics, Components (Engineering Circular//4.1.9/4.5/4.3)
    - Improve prototyping, make better use of test squadron a/c, rotary wing COE
  - Use established or develop new feedback loops for in-service corrosion information
  - Support RDT&E
    - Guide FSTs/programs in common corrosion issues and solutions for new design and upgrades
    - Assess actual corrosion performance compared to design expectations (supports BCAs)
- **RDT&E**
  - Develop multi-year RDT&E plan for NAE corrosion prevention
  - Re-establish aircraft-related S&T corrosion support at ONR and other sponsors
  - Build coalition in NAE to support RDT&E needs in corrosion- CTO
- **Funding**
  - CorrCIP/POM10

FY08 Future Readiness Progress

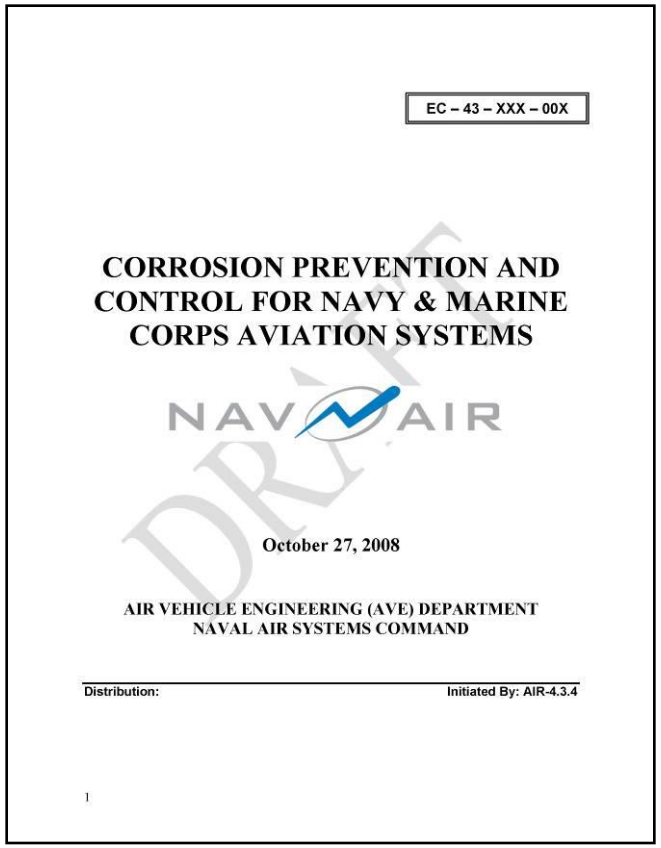
- **Established Corrosion CIP funding for FY10**
  - **Program element and FY10 funding in budget ($309K)**
  - **Execution process drafted**
- **Completed S&T Corrosion point paper advocating re-establishment of corrosion S&T funding**
- **Outlined Corrosion Engineering Circular**
- **Identified FA-XX & EP-X as target platforms for improved contract language**
- **Completed revision of MIL-STD-7179A "DoD Standard Practice for Finishes, Coatings and Sealants"**
  - **Used as acquisition corrosion documentation to defines the primary corrosion prevention and control materials used on the system**

FY09 Future Readiness Plans

- **Complete Corrosion Engineering Circular**
- **Submit Proposals for Corrosion S&T Funding**
- **Execute CorCIP Project Selection Process for FY10 starts**
- **Enhance/stand up Corrosion Action Teams**
  - **F/A-18 A-D/E/F/G**
  - **H-60 B/F/R/S**
- **Execute pilot efforts with FA-XX & EP-X including improved corrosion contact language, trade studies, technology R&D**
- **Revise and Upgrade Specs:**
  - **Revise MIL-S-5002: Surface Treatment and Inorganic Coatings**
  - **Upgrade MIL- HDBK-1250 to STD: Corrosion Prevention and Control for Electronics and Assemblies**

Corrosion Engineering Circular

- **Content**
  - Acquisition
    - Program CPC Guidance
    - System Design CPC Contract Language
    - CPC Trade Study Information
    - Corrosion Verification and Validation Criteria
    - CPC Program Assessment
  - Sustainment
    - CPC Lessons Learned
    - Impact of Corrosion on NAE
  - Appendix
    - Corrosion Airworthiness Requirements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CORROSION PREVENTION AND CONTROL FOR NAVY & MARINE CORPS AVIATION SYSTEMS

NAVAIR

DRAFT

October 27, 2008

AIR VEHICLE ENGINEERING (AVE) DEPARTMENT
NAVAL AIR SYSTEMS COMMAND

Distribution: Initiated By: AIR-4.3.4

1

Corrosion S&T

- **Re-vitalizing working relationship with NRL**
  - Work together on key S&T areas
    - Galvanic modeling, verification and validation testing
    - Low temperature carburization
    - Alloy development
- **Growing links with universities**
  - Projects
  - People
- **Working to Establish ONR Corrosion S&T Funding**
  - Corrosion Innovative Naval Prototype Proposal for “Durable Aircraft”
  - Cold spray

Innovative Technologies for a Maintenance Free Aircraft

November 2008

VISION: Develop galvanic management technologies and engineered systems that eliminate fleet maintenance and reduce life-cycle corrosion cost of aircraft

Major Focus Areas

- **Surface Potential Modeling and Simulation**
- **Tests for Prototyping Corrosion**
- **Engineered Interfaces**

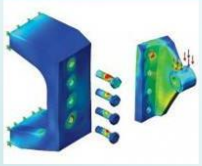
Navy Science & Technology Guidance

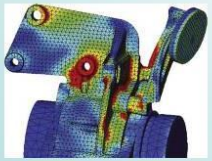
- Seapower 21
- Naval Aviation Enterprise S&T Strategy
- 2009 NAVAL S&T Plan ONR

Surface Potential Modeling and Simulation

Technology solutions will focus on F/A-18, H-60, E-2, and H-53 a/c and future platforms, N-UCAS, F/A-XX.
- highest cost drivers by platform and need
- build upon initial work done by NRL for ships

Vision of Galvanic Modeling Tool: Mapping Galvanic Stress Areas





$$\Delta V = \Delta V^{\circ} - \frac{RT}{nF}\ln\frac{[M_1^{n+}]}{[M_2^{n+}]}$$

Description: Innovative technologies that enable the modeling, simulation and validation of galvanic stress

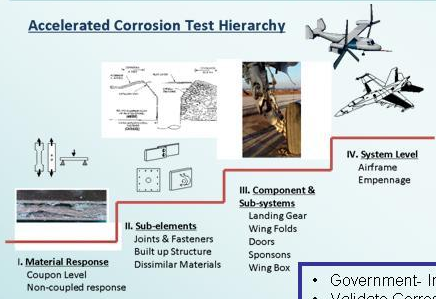
Proposed Investment: $20M for 5 yrs
Investment Technologies (TRL 2):
- computer model of galvanic stress
- validation process for model
- simulator for new design

- Electric Potential Drives Corrosion
- Factors
  - EM Environment
  - Weather / Op Environment
  - Dissimilar Materials
  - Stress
  - Design
  - Coatings
  - Material Degradation

25-Nov-08

Tests for Prototyping Corrosion

Technology solutions will focus on F/A-18, H-60, E-2, and H-53 a/c and future platforms, N-UCAS, F/A-XX.
- highest cost drivers by platform and need
- build upon work underway funded by SERDP



Description: Innovative test technologies that enable prototyping and risk reduction for airframe corrosion performance at sea

Proposed Investment: $15M for 5 yrs
Investment Technologies (TRL 2):
- test and validation process
- prototyping standard
- advanced trade study method

- Government- Industry Accepted
- Validate Corrosion Response
- Realistic and Reliable
- Enables credible design AoA
- Enforceable Contract Language
- Design validation via DT
- Provides Answers
  - How much will it cost/save?
  - How long will it last?
  - What is the ROI?

25-Nov-08

Engineered Interfaces

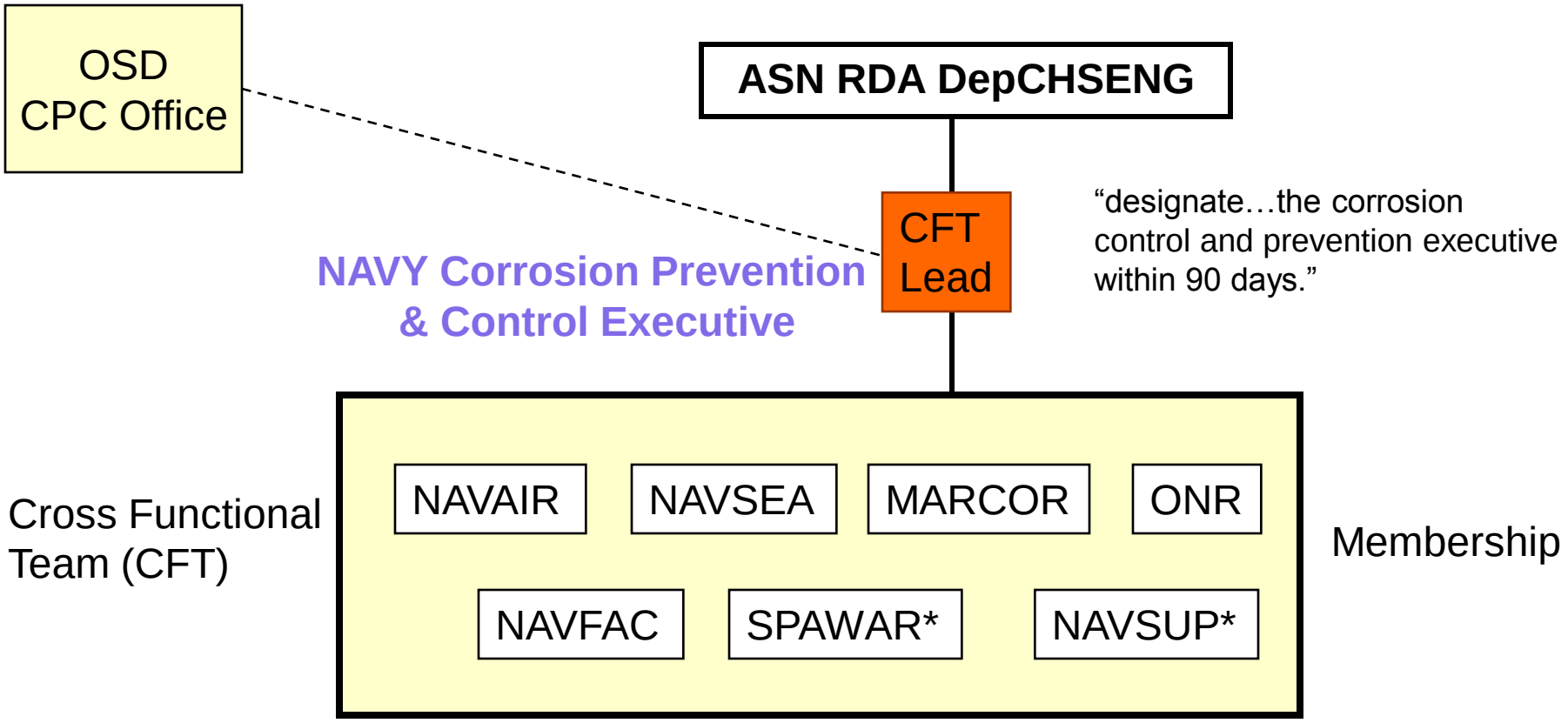
Technology solutions will focus on F/A-18, H-60, E-2, and H-53 and future platforms, N-UCAS, F/A-XX
- highest cost drivers by platform and need
- multiple possible solutions

Description: Develop new technologies that reduce galvanic potential between materials used on airframe

Proposed Investment: $15M for 5 yrs
Investment Technologies (TRL 2):
- Carbon fiber composites with reduced cathode area and less noble open circuit potential
- Multi-compatible fasteners and conductive coatings/sealants
- Galvanically tuned protective coatings

25-Nov-08

NAVY Corrosion Prevention & Control (CPC)



* currently not participating in DOD CPC Forums

National Defense Authorization Act for Fiscal Year 2009

Sec. 903, signed 14 Oct 2008, & 10 USC 2228

Summary

- **Corrosion is a significant cost to the Navy**
  - NAVAIR's total annual budget is ~$40B; annual corrosion cost is estimated at $3.0B
- **The Naval Aviation Enterprise Corrosion Prevention Team is attacking corrosion problem in all phases of aircraft life cycle**
- **Solutions lie in the areas of leadership, training, policy, basing, materials, design, and documentation**